**IN THE UNITED STATES**
**PATENT AND TRADEMARK OFFICE**

**Patent Application**

**Inventors:** Clyde Bethea et al  **Case No.:** 15-11
**Serial No.:** 09/896,783  **Group Art Unit:** 2633
**Filing Date:** June 29, 2001  **Examiner:** Shi K. Li
**Title:** DATA TRANSMISSION VIA DIRECT MODULATION OF A MID-IR LASER

**DECLARATION UNDER 37 C.F.R. § 1.132**

1) I, Rainer Martini received a doctorate in Physics from the University of Aachen, Aachen, Germany. Presently, I am an Assistant Professor of Physics at the Stevens Institute of Technology in Hoboken, New Jersey, U.S.A.

2) My research involves laser physics for optical communications and spectroscopy.

3) I am an author or co-author on, at least 10, scientific articles. I am a contributor to scientific research that has been presented in, at least, 20 scientific conventions.

4) I a co-inventor on above-referenced U.S. Patent Application, i.e., No. 09/896,783.

5) In preparation for this Declaration, I reviewed:

"Generation and Detection of High-Speed Pulses of Mid-Infrared Radiation with Intersubband Semiconductor Lasers and Detectors" by Roberto Paiella et al, IEEE Transactions on Photonics Technology Letters, Vol. 12, No. 7 (July 2000) pages 780 – 782 (Herein, referred to as the "Paiella article".), and

"High-power $\lambda \approx 8$ µm quantum cascade lasers with near optimum performance" by Claire Gmachl et al, Applied Physics Letters, Vol. 72, No. 24 (June 15, 1998) pages 3130 –3132 (Herein, referred to as the "Gmachl article".).

6) Based on my review of the Paiella article and my special scientific training and experience, I make the following conclusion. The Paiella article describes a modulation

scheme in which a quantum cascade (QC) laser is switched between a lasing state and a non-lasing state, i.e., gain switching.

7) Based on my review of the Paiella article and my special scientific training and experience, I conclude that the Paiella article does not disclose DC biasing a QC laser to be within 0.1 volts of the lasing threshold while modulating the laser. In the Paiella article, the last paragraph on page 781, Figure 4, and the caption of Figure 4 do not disclose such a condition on the DC bias voltage during gain-switched operation of the QC laser.

8) Based on my review of the Paiella and Gmachl articles and my scientific training and experience, I conclude that the Paiella article could suggest to one of skill in the art to DC bias a QC laser at more than 0.1 volts from its lasing threshold during gain switched modulation. In particular, the Paiella article describes QC lasers that are very similar to those of the Gmachl article, and the QC lasers of Gmachl article would not be DC biased to within 0.1 volts of their lasing threshold if modulated according to schemes described in the Paiella article. The reasons for this later conclusion are described below.

9) First, the Paiella and Gmachl articles describe similar QC lasers. In particular, the Paiella article states:

> The QC laser is a 1.5-mm-long ~8-μm device [6], based on the 'vertical' transition design in a three-coupled-quantum-well active region, depicted schematically in Fig. 1(b). It was grown by molecular beam epitaxy (MBE) with GaInAs/AlInAs on an InP substrate, with a regrown InP upper cladding layer used to improve thermal dissipation [5], [6]. Its lasing performance is on par with that of similar state-of-the-art 8-μm QC lasers.

The Paiella article, page 781, bottom of left column to top of right column.

That is, the above-cited part of the Paiella article references the Gmachl article, i.e., ref. [6], when describing its own QC laser. Also, the Gmachl article describes its QC laser as having a wavelength of about 8-μm and further states at page 3130, left column, last paragraph, that "[t]he active region consists of three InGaAs quantum wells closely coupled by thin AlInAs barriers." For these reasons, I conclude that both articles describe very similar QC lasers.

10) Second, the QC lasers of Gmachl article would not be DC biased to within 0.1 volts of their lasing threshold if operated according to the modulation and biasing schemes of the Paiella article.

In particular, at page 3131, paragraph 3, the Gmachl article describes its QC lasers as having 30 periods of alternating active regions and injectors. The caption of Figure 1 of the Gmachl article describes one such period as having a sequence of layers with thicknesses: 3.8/2.1/1.2/6.5/1.2/5.3/2.3/4.0/1.1/3.6/1.2/3.2/1.2/3.0/1.6/3.0 where each thickness is in nanometers (nm). From this list, I conclude that one period has a thickness of 44.3 nanometers and that the 30 periods in the QC lasers of the Gmachl article would have a total thickness of 30x44.3 nm = 1329 nm.

The caption of Figure 1 of the Gmachl article also states that the electric field in the laser material is deduced to be 45kV/cm (kilovolts per centimeter) when operated at threshold and at low temperature. Thus, at low temperature, the lasing threshold of the 30 periods of the QC lasers of the Gmachl article is: 1329 nm x 45 kV/cm = 5.98 volts.

11) From the 5.98-volt lasing threshold for the QC lasers of the Gmachl article, it is direct to find the voltages across those QC lasers when DC biased as described in the Paiella article.

At page 781, last paragraph, the Paiella article describes DC biasing a QC laser at 80% of its CW threshold value. This scheme DC biases the QC laser about 20% below the lasing threshold. From the lasing threshold of 5.98 volts, I conclude that such a DC biasing scheme would put the QC lasers of the Gmachl article at 0.20 x 5.98 volts = 1.196 volts below their lasing thresholds in this modulation scheme of the Paiella article.

In the caption of Fig. 4, the Paiella article describes DC biasing a QC laser at 230 mA during gain switched modulation. Also, the threshold current is 250 mA, because page 781, last paragraph of the Paiella article states that 200 mA is 80% of the threshold current. Thus, the gain switching operation in Fig. 4(b) of the Paiella article involves DC biasing the QC laser below its lasing threshold by about (250 – 230)/250 times the lasing threshold voltage. Since their lasing threshold is 5.98 volts, I conclude that the gain

switching scheme of Fig. 4 of the Paiella article would DC bias the QC lasers of the Gmachl article at (20/250) x 5.98 volts = 0.478 volts below their lasing thresholds.

For the above reasons, I conclude that the Paiella article suggests schemes that would DC bias the QC lasers of the Gmachl article to more than 0.1 volts away from their lasing thresholds in the gain-switched modulation schemes of the Paiella article.

12) I herein certify that all statements made of my own knowledge are true and that all statements made on information and belief are believed to be true. I also understand that willful false statements and the like are punishable by fine, imprisonment or both under 18 U.S.C. 1001 and that willful false statements and the like may jeopardize the validity of the application-at-issue or any patent issuing thereon.

Executed on: 08/15/2007
Date

Rainer Martini